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COMPARISON OF DAILY AVIAN MORTALITY CHARACTERISTICS AT TWO TELEVISION TOWERS IN WESTERN NEW YORK, 1970–1999

ARTHUR R. CLARK,[1] COLLEEN E. BELL,[2] AND SARA R. MORRIS[1,2,3]

ABSTRACT.—Recent increases in the demand for communication towers have renewed interest in the impact of these towers on birds, particularly during migration. The objective of this study was to investigate avian mortality at two television towers (WGRZ and WKBW) in western New York from 1970 through 1999. Daily mortality totals ranged from 1 to 1,089 birds. The majority of the kill events were small, involving 10 or fewer birds; however, the majority of birds died in larger kill events. Both kill events and the numbers of individuals salvaged peaked in September. Patterns in avian mortality at the towers that we studied were consistent with normal migration events, during which the number of birds migrating varies substantially between nights. The two towers differed significantly in kill characteristics. At the WGRZ tower, median daily mortality generally ranged from 1 to 10 birds and was usually lower than at the WKBW tower. The size of kill events varied across the 3 decades, with no very large kill events (>500 birds) occurring in the 1990s. Because most birds salvaged in the 1970s and 1980s were killed in medium and large kill events, the absence of any very large kill events in the 1990s could explain the previously published decline in birds salvaged at these towers. *Received 24 May 2004, accepted 7 February 2005.*

Although the Migratory Bird Treaty Act of 1918 prohibits human interference with migratory birds, lighted man-made structures, such as communication towers, have been responsible for the deaths of many nocturnal migrants (Avery et al. 1980). Avian mortality at communication towers (tower kill) results from collisions of birds with the towers themselves or their supporting guy cables. In the United States, there are more than 83,000 towers (Federal Communications Commission 2004), and the number of tower kills is likely to increase as tower construction continues. Many factors affect the number of nocturnal migrants colliding with towers, including density of migrants aloft, weather, tower location and elevation, tower height, number and location of guy cables, and lighting. Northerly winds spur bird migration in the fall, and overcast conditions may disorient birds, resulting in their gravitation toward lighted towers (Clark 1973).

Only a few long-term studies have documented the effects of specific towers on avian mortality. Crawford and Engstrom (2001) noted that the pattern of avian mortality they witnessed at a northern Florida television tower was "distinctly seasonal," with most of the kill events occurring during fall migration. In a study of tower mortality in western New York and Ohio, Morris et al. (2003) documented a significant decline in the number of salvaged birds over a 30-year period. This decrease could result from fewer kill events, smaller kill events, or both.

The goal of our study was to examine patterns of avian mortality at two television towers in western New York. Specifically, we documented temporal patterns in the kill events, both within the autumnal migratory period and among the last 3 decades.

METHODS

We examined fall avian mortality at two television towers in southern Erie County during the 30-year period from 1970 to 1999. The WGRZ tower is located in Wales, New York (78° 33′ N, 42° 43′ W); it is 261 m tall, not including a 32-m antenna, and was erected in 1968. This tower sits at an elevation of 412 m asl and is supported by 15 guy cables. Additionally, it is illuminated at night by three levels of constantly burning, red obstruction-warning lights (three lights per level, 116 watts each) and three levels of slowly flashing, red beacon lights (1,240 or 1,400 watts each). The WKBW tower is located in Colden, New York (78° 37′ N, 42° 38′ W); it is

[1] Buffalo Museum of Science, 1020 Humboldt Pkwy., Buffalo, NY 14211, USA.

[2] Dept. of Biology, Canisius College, 2001 Main St., Buffalo, NY 14208, USA.

[3] Corresponding author; e-mail: morriss@canisius.edu

TABLE 1. Annual variation in daily avian kill events at two television towers in western New York during fall migration, 1970–1999.

	WGRZ					WKBW				
Year	Number of visits	Number of kill events	Median[a]	Range	Total no. of birds killed	Number of visits	Number of kill events	Median[a]	Range	Total no. of birds killed
1970	NA[b]	18	14.5	1–630	1,828	NA[b]	12	14.5	1–90	240
1971	67	23	11	1–361	852	67	28	5	1–72	434
1972	NA[b]	9	5	1–98	174	NA[b]	2	4.5	2–7	9
1973	NA[b]	11	5	1–88	158	NA[b]	8	7	1–17	69
1974	NA[b]	15	9	1–51	237	NA[b]	8	27.5	1–307	829
1975	NA[b]	9	38	3–458	1,066	NA[b]	8	64	3–686	1,312
1976	17	14	8.5	1–110	304	12	8	13.5	2–55	170
1977	15	10	7.5	1–170	391	13	11	5	1–445	1,026
1978	27	12	10	1–70	209	13	8	4	1–114	171
1979	25	14	6	1–63	179	15	15	9	1–138	345
1980	29	13	9	1–135	331	15	9	4	1–659	984
1981	13	5	5	1–100	116	6	4	12.5	1–91	117
1982	24	19	13	1–437	1,189	18	15	35.5	1–1,089	3,306
1983	21	7	2	1–76	97	11	3	11	3–23	37
1984	16	12	3	1–42	116	9	5	22	1–98	178
1985	20	9	4	1–68	173	8	4	45.5	1–159	251
1986	17	6	4	1–40	63	7	3	11	6–113	130
1987	12	1	1	1	1	5	4	1.5	1–42	46
1988	10	4	7	3–98	115	7	4	17.5	1–262	298
1989	12	3	1	1–72	74	5	3	58	2–332	392
1990	16	9	4	1–43	83	8	5	22	2–65	140
1991	13	5	1	1–8	19	4	2	5	1–9	10
1992	10	4	1	1–2	5	2	1	1	1	1
1993	8	6	3	1–60	75	4	3	6	3–15	24
1994	12	6	1	1–15	23	3	2	37.5	12–63	75
1995	10	7	2	1–10	20	4	3	2	1–3	6
1996	12	8	3	1–13	36	9	5	28	2–294	426
1997	12	7	1	1–10	26	5	3	3	1–9	13
1998	15	8	1	1–3	12	5	2	1	1	2
1999	23	11	3	1–13	45	13	7	5	1–23	51
Total	518	285	4[c]		8,017	306	195	6[c]		11,092

[a] Median number of birds collected after nights with kill events (nights with no birds were excluded).
[b] The number of days visited without finding birds was not recorded in the early 1970s.
[c] Overall median was based on all kill events, not on annual medians.

305 m tall, not including a 23-m antenna, and was erected in 1958. This tower sits at an elevation of 529 m asl and is supported by 18 guy cables. The WKBW tower has four levels of red obstruction-warning lights and four levels with red beacon lights and is located approximately 8 km south-southwest of the WGRZ tower. Both towers are a lattice of steel, and triangular in cross-section, typical of many television and radio towers. Both tower sites have paved driveways, small parking lots, and transmitter buildings. Immediately surrounding the facilities are grass lawns cut lower than surrounding grass. At WKBW, the taller grass fields were cut in early fall during most years of the study. At WGRZ, there were larger areas of cut grass and pavement to the south of the tower. The taller grass fields were used as pasture in the early years of the study, with occasional cuttings in the later years.

With the assistance of volunteers, ARC salvaged birds from the WGRZ and WKBW towers. Visits to towers generally occurred from late August to early November, following nights with overcast or mostly overcast skies and with northerly winds or winds becoming northerly. Although records were kept of most visits during which no salvaged birds were recovered, this information was more thoroughly documented after 1975 (Table 1). The search procedure involved checking the

TABLE 2. Top five families of birds killed at two television towers in western New York, 1970–1999. Most of the birds salvaged at both towers were members of Parulidae, Turdidae, Vireonidae, and Regulidae.

Total birds killed at each tower by family	
WGRZ	WKBW
5,055 Parulidae	7,410 Parulidae
1,030 Turdidae	1,694 Turdidae
689 Vireonidae	1,086 Vireonidae
624 Regulidae	346 Regulidae
337 Emberizidae	207 Mimidae

paved and grassy areas around the towers for birds by walking in loops (ranging out to approximately 50 m at WGRZ and 60 m at WKBW) through the lower-cut grass lawns and by walking straight lines under the guy cables to about 65 m from the base of the tower, and by returning about 2 m south of the cables. The searches included additional loops out into taller grass to approximately 30 m from the tower in the two southerly facing angles of the guy cables.

Searchers increased coverage of grassy areas when specimens were found, walking a series of parallel paths approximately 1 m apart on the lower-cut grass lawns. Searchers walked similar patterns in the taller grass, extending well beyond the last specimen collected. Using binoculars, searchers also checked the angled roof of the WGRZ transmitter building for birds (Morris et al. 2003).

To compare avian mortality across decades, we designated kill sizes as small (1–10 birds), medium (11–100 birds), and large (>100 birds). We used likelihood ratio chi-square tests to analyze differences in kill sizes between towers and among decades at each tower, and differences in the number of individuals in kill events among the 3 decades. We examined temporal patterns during fall migration by 10-day periods beginning 1 August. We salvaged birds between 12 August and 16 November, resulting in 10 pooling intervals. Because of limited collections in August and November, we combined the first two periods into a single initial interval, and the last two periods into a single final interval, resulting in eight intervals for statistical analysis. We pooled data across each decade to investigate temporal changes during the 30-year period. We present median kill sizes because distributions were not normal. All analyses were performed using SYSTAT (SPSS, Inc. 2002). Significance levels were determined after sequential Bonferroni correction for multiple tests (Rice 1989), although uncorrected *P*-values are presented.

RESULTS

From 1970 through 1999, 11,092 birds were collected at the WKBW-TV tower, and 8,017 birds were collected at the WGRZ-TV tower. At least one bird was salvaged most nights (WGRZ: 55.0%, $n = 518$; WKBW: 63.7%, $n = 306$), although nights on which no birds were collected were not always noted, particularly in the early 1970s (Table 1). The families represented most frequently were similar at the two towers (Table 2). The top

TABLE 3. The most commonly killed avian species were similar at two television towers in western New York, 1970–1999.

Species	Total killed at WGRZ	Species	Total killed at WKBW
Ovenbird (*Seiurus aurocapilla*)	907	Bay-breasted Warbler	1,359
Magnolia Warbler (*Dendroica magnolia*)	555	Ovenbird	1,303
Swainson's Thrush (*Catharus ustulatus*)	531	Magnolia Warbler	986
Bay-breasted Warbler (*Dendroica castanea*)	494	Swainson's Thrush	865
Blackpoll Warbler (*Dendroica striata*)	487	Red-eyed Vireo	806
Red-eyed Vireo (*Vireo olivaceus*)	472	Black-throated Blue Warbler	437
Golden-crowned Kinglet (*Regulus satrapa*)	444	Blackpoll Warbler	405
Black-throated Blue Warbler (*Dendroica caerulescens*)	348	Tennessee Warbler (*Vermivora peregrina*)	391
American Restart (*Setophaga ruticilla*)	239	Common Yellowthroat (*Geothlypis trichas*)	366
Black-throated Green Warbler (*Dendroica virens*)	227	Black-throated Green Warbler	325

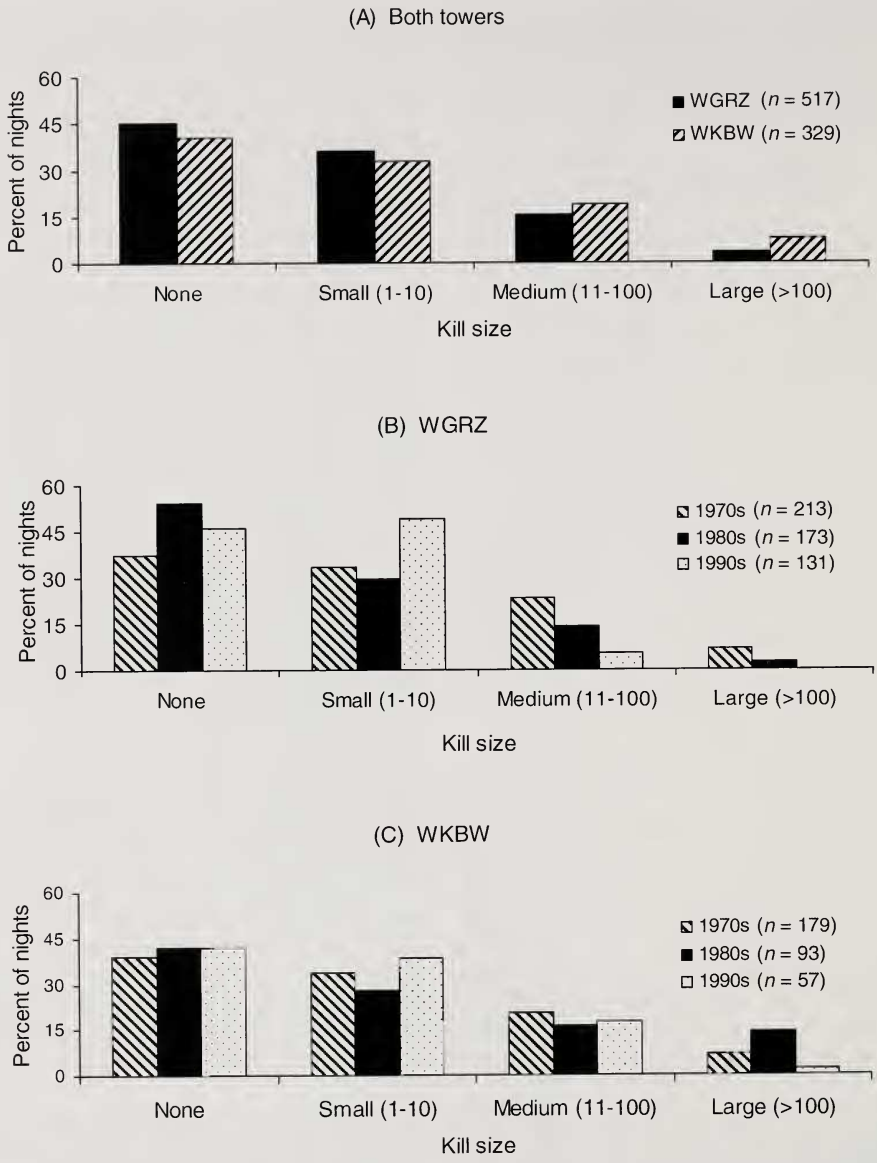

FIG. 1. Kill events at two television towers in western New York, 1970–1999: (A) totals for each tower; (B and C) totals by decade for the WGRZ and WKBW towers. The majority of collections resulted in 100 or fewer birds killed during a single night.

ten species killed at each tower represented >50% of the total individual birds killed, and all but one of these species were Neotropical migrants (Table 3).

The number of birds killed per night ranged from 1 to 1,089 at WKBW and from 1 to 630 at WGRZ. Kill events on most nights involved 10 or fewer birds (Fig. 1). The median kill size (all years) was four at WGRZ and six at WKBW (Table 1). We detected a slight but significant difference in the proportion of small, medium, and large kill events between the two towers ($\chi^2 = 8.5$, df = 2, $P = 0.014$; Fig. 1A). The proportion of small, medium, and large kill events was dependent on decade (WGRZ: $\chi^2 = 30.6$, df = 4, $P < 0.001$;

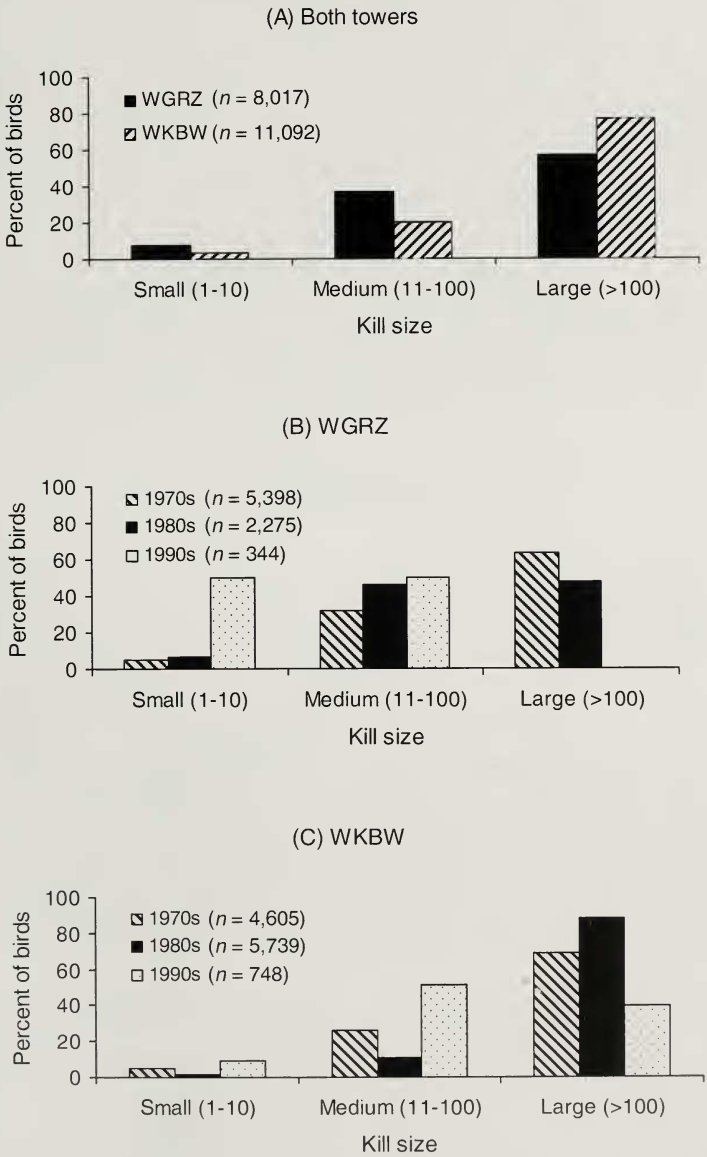

FIG. 2. Birds salvaged at two television towers in western New York, 1970–1999: (A) percent salvaged at each tower; (B and C) percent salvaged by decade for the WGRZ and WKBW towers. A relatively small percentage of salvaged birds was collected after nights when kill sizes were small (10 or fewer).

WKBW: $\chi^2 = 10.0$, df = 4, $P = 0.040$), with a higher proportion of small kill events in the 1990s at both towers (Fig. 1B, C).

Although most kill events involved 10 or fewer birds, the majority of birds were salvaged after medium to large kill events (>10 birds; Fig. 2). The majority of individuals were killed in large events during the 1970s and 1980s at both towers, while the majority of individuals were killed in small and medium events in the 1990s (WGRZ: $\chi^2 = 987.7$, df = 4, $P < 0.001$; WKBW: $\chi^2 = 1,101.5$, df = 4, $P < 0.001$; Fig. 2B, C). During the 1990s, there were substantially fewer birds collected overall, and no single kill event resulted in a very large kill (>500 individuals). The largest kill event during that decade at WGRZ was only 60 birds; only one kill event was >100 birds at WKBW (294 birds on 10 September 1996).

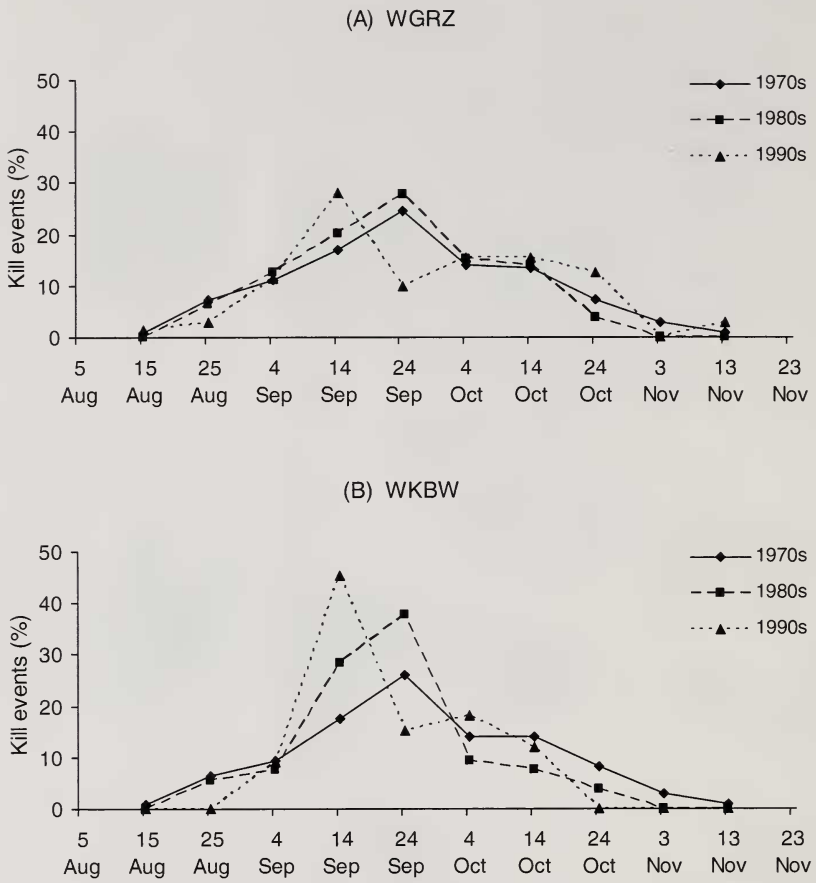

FIG. 3. Kill events (%) by 10-day salvage intervals at two television towers in western New York, 1970–1999. At both towers, the largest percentage of nights during which birds were killed occurred during September.

Kill events occurred throughout autumn migration, with most occurring during September (Fig. 3). The proportion of kill events by 10-day salvage interval did not differ among the 3 decades (WGRZ: $\chi^2 = 20.1$, df = 14, $P = 0.126$; WKBW: $\chi^2 = 25.9$, df = 14, $P = 0.027$; not significant after Bonferroni correction). Similar to the timing of kill events, the largest proportion of migrants was salvaged in September (Fig. 4). In the 1970s and 1980s, the largest kill events occurred in mid-September, while in the 1990s, the largest kill events occurred in early September. This pattern was observed at both WGRZ and WKBW; additionally, the proportion of salvaged birds by 10-day interval differed among the 3 decades (WGRZ: $\chi^2 = 926.2$, df = 14, $P < 0.001$; WKBW: $\chi^2 = 2{,}583.8$, df = 14, $P < 0.001$). These analyses are dependent on the timing of visits to the tower sites; thus, we investigated whether the timing of visits varied across the 3 decades. We found no difference in the proportion of visits to towers by 10-day salvage interval for both towers (WGRZ: likelihood ratio $\chi^2 = 17.7$, df = 14, $P = 0.22$; WKBW: likelihood ratio $\chi^2 = 24.6$, df = 14, $P = 0.039$; not significant after Bonferroni correction). The slight difference in the timing of visits at WKBW across the 3 decades was due to the highest percentage of visits occurring in mid-September in the 1990s (30.4% of all visits) versus late September in the 1970s (19.3%) and 1980s (27.0%).

DISCUSSION

Avian mortality at towers may reflect not only the abundance of migrants, but also the weather conditions migrants experience. Furthermore, individual communication towers appear to differ in their impact on migrants.

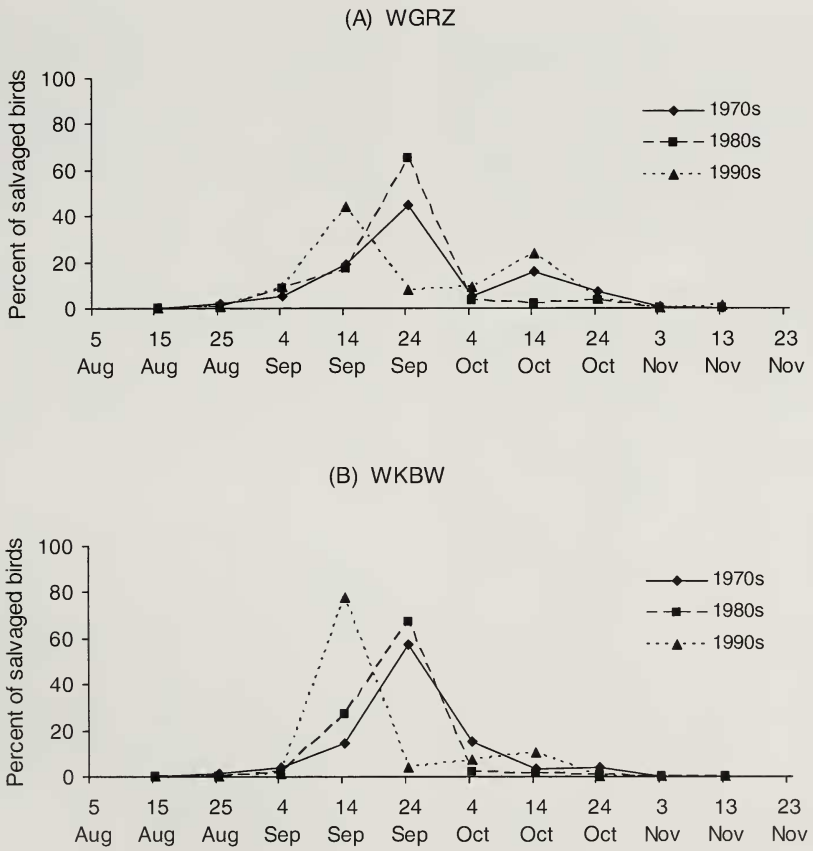

FIG. 4. Salvaged birds (%) by 10-day intervals at two television towers in western New York, 1970–1999. Most birds were collected during September.

Thus, finding dead birds at either tower in this study most likely indicated migration was occurring. However, even nights with appropriate wind conditions for migration (northerly) did not always result in substantial avian mortality. Most visits to both television towers resulted in the salvage of migrants. Although most visits resulted in the salvage of 10 or fewer birds, on some we recorded large kill events (>100 birds). These results are similar to those from a study in northern Florida, in which small kill events occurred on more than 80% of days (Crawford and Engstrom 2001). Likewise, Crawford and Engstrom (2001) reported a very low percentage of very large kill events (0.1% of days resulted in the salvage of >500 individuals); the combination of appropriate wind conditions and cloud cover were necessary for substantial kill events (Clark 1973, Crawford and Engstrom 2001). Nights with no birds salvaged were frequent in this study and may reflect a lack of migration or weather conditions that were not conducive to tower kills.

Crawford and Engstrom (2001) noted that more than 40% of birds were salvaged from kill events of 11–100 birds. Furthermore, although only one bird was salvaged after >30% of nights, only approximately 2% of all individuals were salvaged after those nights. Our results are similar in that only a very small percentage of birds were from salvages of single individuals, and most of the birds we salvaged were collected after medium (11–100 birds) or large (>100 birds) kill events.

We did find slight but significant differences in the sizes of kill events between the two towers studied. Detailed comparisons of avian mortality can be hampered by a number of variables whose effects may be difficult or impossible to isolate. The two towers in this study, although structurally similar, differ in

elevation at ground level, tower and antenna height above ground, number and placement of guy cables, building and grounds lighting, surrounding habitat, and proximity to other towers (Clark 1973, Morris et al. 2003). The WKBW tower had a higher proportion of large kill events than the WGRZ tower, was taller and located at a higher elevation, and had more guy cables.

Previous work has documented that significantly more birds were killed at these television towers in the 1970s and 1980s than in the 1990s (Morris et al. 2003). Thus, it is not surprising that the majority of individuals were salvaged from large kill events (>100 individuals) during the 1970s and 1980s. The decrease in the number of birds salvaged during the 1990s reflects the smaller kill events documented in the results presented here. Reasons for the decline in the number of birds salvaged remain unknown, although the declines may reflect a decline in migrant populations (Goodpasture 1984), a change in weather patterns (Goodpasture 1984), selection against lower-flying migrants, an increase in anthropogenic nocturnal lighting (Morris et al. 2003), and/or an increase in predation on the avian casualties at towers (Stoddard 1962, Goodpasture 1984, Crawford and Engstrom 2001).

Peak kill events at both towers occurred in mid-September during the 1970s and 1980s, whereas during the 1990s, kill events peaked in early September. Likewise, the majority of individual birds were salvaged in mid-September for both towers in the 1970s and 1980s, while in the 1990s the peak occurred in early September. Fall migration in western New York generally shows a peak in September, particularly among Neotropical migrants (Buffalo Ornithological Society 2002). Because there were few large kill events in the 1990s (and, therefore, our salvage data for the 1990s are based only on small and medium kill events), our results may not reflect any real change in migration timing across decades.

Although most tower kill events, particularly in recent years, have been small at individual communication towers, the cumulative impact of small kill events at thousands of towers may greatly impact migrant populations. Migration is an extremely hazardous period for birds. Among Black-throated Blue Warblers (*Dendroica caerulescens*), for example, approximately 85% of annual mortality may occur during this period (Sillett and Holmes 2002). Many causes may contribute to mortality during migration, but clearly collisions with communication towers have an impact on migrant populations. It is speculated that millions of birds are killed at communication towers annually, and this threat is expected to double in the next decade as the proliferation of communication towers continues (Holden 2001). The relative impact of collisions with towers and other causes of mortality during migration require additional study.

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